Standardization: bridging the gap between economic and social theory

Keil, Thomas ; Fomin, Vladislav

Abstract: This article examines the dynamics of inter- and intra-firm networks in technical standard setting initiatives, and how complex social networks align in these initiatives. Specifically, we argue that in standardization, complex economic and social interactions are blended. In standardization activities, firm behavior and the behavior of individuals within firms is best explained through an integration of social, political, and economic perspectives. In this article we use two main bodies of theory. First, we draw on the economic literature on standard setting and alliance formation. Second we use social network theory to complement economic arguments. In this paper we integrate streams of literature on the creation and diffusion of technical standards from industrial organization economics, strategic management, and innovation economics with recent literature concerning the social construction of technology in order to analyze the process of standard setting. We develop our arguments with the help of three in-depth case studies of standardization initiatives in the telecommunications industry. Two case studies are in the realm of telecommunications infrastructure. The third case study analyzes the standardization of a wireless data link. The cases can be characterized as examples of the successful creation of both de facto and de jure standards.

ICIS Proceedings

ICIS 2000 Proceedings

Association for Information Systems *Year* 2000

Standardization: Bridging the Gap Between Economic and Social Theory

Vladislav Fomin* Thomas Keil†

*University of Jyväskylä

†Helsinki University of Technology

STANDARDIZATION: BRIDGING THE GAP BETWEEN ECONOMIC AND SOCIAL THEORY[1]

Vladislav Fomin
STAMINA Research Group
Faculty of Information Technology
University of Jyväskylä
Finland

Thomas Keil
Institute of Strategy and International Business
Helsinki University of Technology
Finland

Abstract

This article examines the dynamics of inter- and intra-firm networks in technical standard setting initiatives, and how complex social networks align in these initiatives. Specifically, we argue that in standardization, complex economic and social interactions are blended. In standardization activities, firm behavior and the behavior of individuals within firms is best explained through an integration of social, political, and economic perspectives. In this article we use two main bodies of theory. First, we draw on the economic literature on standard setting and alliance formation. Second we use social network theory to complement economic arguments. In this paper we integrate streams of literature on the creation and diffusion of technical standards from industrial organization economics, strategic management, and innovation economics with recent literature concerning the social construction of technology in order to analyze the process of standard setting.

We develop our arguments with the help of three in-depth case studies of standardization initiatives in the telecommunications industry. Two case studies are in the realm of telecommunications infrastructure. The third case study analyzes the standardization of a wireless data link. The cases can be characterized as examples of the successful creation of both de facto *and* de jure *standards.*

1. INTRODUCTION

Technological standards play an important role in many high technology industries. Standardization is a major challenge in the system development/implementation process. It is also emerging as a key challenge and enabler of business-to-business (B2B) electronic commerce. In industries such as computer technology, telecommunications, and consumer electronics, the setting of or at least influencing technical standards has become one of the core strategic challenges. In these industries, competition often takes a "winner takes all" form, in which the firm that successfully establishes a technical standard receives large returns, whereas its competitors may be effectively locked out of the market (Schilling 1998).

[1]Both authors were supported through grants from the Academy of Finland. We would like to express our gratitude for this support. Fomin also acknowledges members of STAMINA group for helping with interview materials and creating a fertile working atmosphere: Kalle Lyytinen, Juha Knuuttila, Ari Manninen, Ping Gao, Anri Kivimäki, Joel West, and John King. Keil acknowledges the support of the research group at ISIB, especially the valuable discussions with Erkko Autio. We would further like to thank the managers in the case companies for their time and efforts in this study. The credit for all remaining errors and shortcomings belongs to the authors of this paper.

In this article we examine **standardization** as a process of standard making, whereby "*a '**standard**' is to be understood, for the present purposes, as a set of technical specifications adhered to by a producer, either tacitly or as a result of a formal agreement"* (David and Greenstein 1990, p. 4). Despite its importance, our understanding of the process of setting standards and establishing a standard's dominance in the marketplace is still relatively limited and fragmented. Theories commonly used in the IS/IT domain to explain management phenomenon are primarily based upon a technical-economic rationality (Kumar et al. 1998). In economics, the early literature analyzed standardization as a rational game between the actors involved (Besen and Farrell 1994). Comparably less attention has been given to the processes through which technology is standardized. In the management domain, mainly the nature of dominant design competition and bandwagon processes have been studied (Tushman and Anderson 1986; Wade 1995). Disconnected from this body of literature, a social network literature of standardization has emerged (Williams and Edge 1996). This literature has modeled standardization as a social negotiation and sense-making process. The link between the actual creation of a technical standard and its diffusion into a market has been largely ignored.

This paper contributes to filling this gap in the literature. It integrates literature about the creation and diffusion of technical standards from industrial organization economics, strategic management, and innovation economics with recent literature concerning the social construction of technology in order to analyze the process of standard setting. In particular, we analyze how processes of strategizing, sense making, and negotiation jointly explain the emergence and success of technical standards.

Our arguments are developed with the help of three in-depth case studies of standardization initiatives in the telecommunications industry. Two case studies are in the realm of telecommunications infrastructure. The third case study analyzes the standardization of a wireless data link.

2. RECEIVED THEORY

2.1 Economic and Strategic Management Literature

Economic theory has studied why standards emerge, how technology adoption progresses, and the welfare implications of the emergence of standards. Attempts to model standardization processes have often used game theoretic model setups. In a pioneering work, Farrell and Saloner (1988) compare standardization using market mechanisms and committees in a game theoretic framework. Farrell et al. (1994) discuss the emergence of standardization alliances in a game theoretic model. They analyze some of the incentives and disincentives of joining into standardization alliances.[2]

Game theoretic models of standardization differ in their definition of the underlying structure of the game. What they share is the assumption of purely rational actors. By "rational game" we understand any form of business transactions—e.g., cooperation, non-cooperation, any other strategic behavior—between two or more parties based on some sort of economic calculus. In general, economic literature assumes that the parties are seeking economic benefits from the business transactions undertaken. The effects of social relationships and the forces that these exert on the decisions of actors are ignored. Thus, the critique that has been voiced of other economic theories, such as transaction cost economics (Ghoshal and Moran 1996; Granovetter 1985, 1992) equally apply for game theoretical models. Game theoretic models would seem to be better suited in identifying possible dominant outcomes from standardization processes rather than the process of reaching any of the possible outcomes. Taken together, they are only to a limited extent suitable to model the complex socio-economic processes that underlie the standardization of complex technological systems.

A second class of economic models of standardization has been concerned more with the diffusion of technologies and the emergence of *de facto* standards. These models often are based on notions of increasing returns (Arthur 1989). The basic mechanism that these models describe is that a technology gains an initial lead in the installed base of the technology. This lead triggers a bandwagon process in which new members adopt the technology. Adoption of the technology in return increases the attractiveness to third parties to support this technology. Third party support again encourages new users to adopt the technology. This circle amplifies the initial lead of the technology (or technological standard) until it has driven other standards out of the market. A fragmentation of market is also possible. There are several possibilities. First, the group that chooses the losing standard might be big enough or in some respect special enough to support this standard, e.g. as in the case of Apple Macintosh vs. PC. Second, none of the standards might gain enough advance to trigger new increasing returns. In the management literature, the literature on the emergence of dominant designs is especially relevant for the study of standardization. In a product class, once a dominant design emerges, competition shifts from competition between designs to competition elaborating the design, that is, competition within the boundaries set by the design (Anderson and Tushman 1990; Tushman and Anderson 1986). Complex

[2]See also Axelrod et al. (1995) for empirical investigations on alliance formation.

socio-political processes appear to be relevant in addressing the issue (Tushman and Rosenkopf 1992). The precise nature of these processes is, however, beyond the scope of this research.

More recent work has tried to model the processes of standard selection by using bandwagon models similar to economic theory. Wade (1995, 1996) argues that the existence and composition of organizational communities is one factor that determines the start of a bandwagon effect. Wade defines organizational communities on compatibility as well as on sponsorship of the standard. Thus, communities include firms that are allied around a technological standard as well as firms that simply adopt it. Wade's results show impressively that inter-organizational relationships play an important role in the evolution of standards. However the processes within communities need to be examined to be able to model the emergence and rise to dominance of a technological standard. The processes firms use to attract others to join in the bandwagon process are only insufficiently understood.

To summarize, the review of the economic and strategic management literature indicates that economic arguments do not suffice in explaining the standardization phenomena. Rather, social and political processes play an important role in processes that lead to technical standards and their success or failure in the market. In the next section, social theories of standardization are reviewed.

2.2 Social Network Theory of Standard Setting

For a long time researchers and practitioners have argued that a simple Schumpeterian understanding of market forces, positing that a superior technology will be chosen by the market, lacks an understanding of the influence of the socio-institutional environment upon the innovation (Choh 1999; Pinch 1988). Environmental factors force us to expand on economic reasoning by acknowledging the influence of governmental and regulative bodies, industrial consortia, the institutional and technical culture of the developers and the adopters of the innovation. While being technically very similar to each other, and being developed at the same time, some technological systems receive more or less acceptance, and some witness no commercial success. This fact suggests that technology is not an artifact with predetermined features and impact on the market (Lyytinen and Damsgaard 1998; Pinch 1988). Neither the market, nor the technology under development are closed systems; both are subject to the influence of the socio-institutional forces (Choh 1999).

Rogers' (1995) diffusion of innovation theory (DOI), first published in the 1970s, forms the base for technology diffusion models. DOI adopts a micro level perspective on diffusion of innovation and focuses on socio-cultural aspects, although its main interest is on the diffusion of technology. The model assumes unlimited communication within the social system where the information of innovation is communicated from one member of a community to another. In contrast to some economic views of the diffusion process (e.g., Besen and Farrell 1994), the behavior of adopters is seen as not necessarily being rational. By failing to account for influences brought in from an external environment, the DOI models exclude network externalities—a notion crucial in understanding diffusion of networked technology (Heikkilä 1995; Lyytinen and Damsgaard 1998). Although there are notable downfalls in DOI theory, it forms a baseline for a substantial stream of the literature on innovation studies and cannot be disregarded.

If using economic literature helps in finding a possible outcome of a standard setting process, or "what" will be the outcome, then social stream of literature will analyze "why" the process development has followed one or another trajectory. Power relations theory Star (1991) tries to weigh up the influence and power that particular actors possess and how power is used in the decision-making process. Decision making, in turn, determines the trajectory, according to which a particular technology develops.

Additional contributions arise from theories of knowledge creation (Cowan and Foray 1997; Michelis 1997; Nonaka and Takeuchi 1995). Similar to the power relations theory, this approach also fails to account for the role of technology in the path of technological development. Nonetheless, it is worth considering knowledge creation theory for the reason that technological development often involves the combination of knowledge of different technical fields, as well as expertise in non-technical areas (Williams 1997, p. 303). One should not assume that the knowledge creation seizes when what is called the knowledge creation cycle is over. The terms "knowledge creation" and "market diffusion" are brought forth by scholars to distinguish between specific settings and/or emphasis of particular business processes. While important in understanding the innovation and diffusion processes, knowledge creation theory addresses these two processes as separate, and thus is limited in its use for a comprehensive analysis of the standardization process.

An additional approach is proposed by actor network theory (ANT). This theory posits that decisions are made after the alignment of interests of the involved actors takes place. The alignment of interests is one of the possible outcomes of the continuous negotiation process, in which the actors are involved (Callon 1986; Callon and Law 1989; Latour 1993). In contrast to other aforesaid theories, ANT acknowledges the role of technological artifacts in the innovation process. The theory assumes the equal

importance of human and non-human actors in the process of the aligning of interests. Another important contribution of actor network theory is that it abandons the traditional micro/macro divide.

Actor network theory helps to address issues of technological development process by addressing actors who possess enough power to change the direction in which the technology develops at critical passage points. These actors, who can significantly influence the development trajectory of the process, are referred to as gatekeepers.[3] Our approach to standardization is to identify key stages in the process and the gatekeepers associated with them, and to track the negotiation process of interests of the involved actors. We use Callon's notion of "translation" to describe the outcome of the negotiation process (Callon et al. 1986). According to Callon (1992), a successful translation stabilizes the network of actors, which means that the involved parties are not only brought together, but have a stable base and commitment to go ahead with the innovation, whether it be a development or an adoption process.

To summarize, several weaknesses in the economic and strategic management and in the social network literature can be stated (see Table 1). First, while logical connection points between economic and social theory have been identified, for instance in the work of Tushman and Rosenkopf (1992), the integration of these bodies of theory has not proceeded very far. Second, the existing literature on standardization has often only been concerned with part of the standardization process. Authors have either been concerned with the creation of the standard (Farrell and Saloner 1988), or with the choice and diffusion of the standard (Tushman and Anderson 1986). Only a few studies have tried to capture the whole standardization process, from the inception of the idea to business implementation (Fomin and Lyytinen 2000; see Table 2). In other words, although each of the theories is relevant for the standardization process analysis, none can adequately embrace the complexity of such. In the following section, we will present an overview of the cases and show applicability of certain theories to account for the cases presented.

3. TOWARD A SOCIO-ECONOMIC THEORY OF STANDARDIZATION

> *Standards making is wholly a social practice that has gradually developed through pragmatic commercial and social necessity—not through any theoretical impetus.* (Schoechle 1999, p. 175).

The authors of this work aim at a theory of standard making, which would facilitate the analysis of the standardization practices within the IT field. The objective of the work is to show that the presented approach can be generalized and successfully used not only for the standardization practices that took place in the past, but also for these to take place in the future.

3.1 Case Methodology

We derive our theoretical arguments based on three cases of standardization processes. We use these cases to develop our integrative theory of standard setting and diffusion processes, whereas *"a theory can be considered as a 'thought artifact' constructed by humans with the purpose of describing and explaining phenomenon"* (Kumar et al. 1998, p. 201). Thus, our methodology is motivated by both our concern for processes and for theory building. We conduct an interpretive investigation by identifying the important passage points in the case processes and explaining the outcomes by mapping the cases on relevant theoretical arguments.

Our concern is with highly complex processes that take several years to unfold. The case method is well suited to capture the richness and complexity of these processes (Yin 1994). First, data was collected in order to develop a rich description of the cases. Interviews with managers in the standardization processes were conducted. The interviewed managers were either key decision makers or standardization specialists involved in the cases.[4] Written documents, memos and public announcements were used to corroborate the findings from the interviews wherever possible. Second, interpretive theories were used together with the collected data to interpret and develop an original understanding of the observed behaviors. A strategy of inductive theory discovery coupled with the interpretation of observations through the lenses of different theories allowed for the development of a theoretical account of the phenomenon while simultaneously grounding the account in empirical observations or data (Eisenhardt 1989; Glaser and Strauss 1967).

---

[3]Also called "door keepers" (Star 1991).

[4]For instance, in the cases of the NMT and GSM cellular telephone systems, former chairmen of the standardization committees were interviewed. For confidentiality reasons, we cannot disclose all the names of the interviewed managers.

Table 1. Theories Used to Analyze Standardization Process

Theory/Model	Focus	Outcome	Explanatory Mechanisms	Deficiencies
A. Game theoretic: standard selection (Besen and Farrell 1994; Farrell and Saloner 1988)	Selection of type of standard: – committee – market – hybrid	Competing within vs. between standard(s). Fast vs. slow process	Rational (bounded rational) behavior of actors	Social forces are ignored. Determines outcomes, but can not account for process
B. Game theoretic: alliance formation (Axelrod et al. 1995)	Establishing alliances (selection of standard)	Joining in with: – collaborators – competitors – none	Rational (bounded rational) behavior of actors	Ignores timing of joining the alliance. Assumes acceptance of any member
C. Increased returns (Arthur 1989)	Selection/adoption of standard. Formation of dominant design	Dominant design. From competing between to within the standard	Adoption of technology increases attractiveness to third parties to support the technology	Points to complex socio-political processes, but does not answer "whys"
D. Bandwagon (Wade 1995, 1996)	Selection/adoption of standard. Formation of dominant design	Dominant design	Selection determined by organizational communities. Compatibility or sponsorship criterion	Processes within community are not addressed
E. Diffusion of Innovation (Rogers 1995)	Diffusion of innovation process	Character of innovation's adoption	Communication of information on innovation within a social ether	Assumes unlimited communication. Limited to micro level analysis
F. Power relations (Star 1991)	Decision making process	Explaining particular decision	Accounts for power and influences of individuals	Limited to micro level analysis
G. Knowledge creation (Cowan and Foray 1997; Michelis 1997)	Communication of knowledge	Expertise for standard creation. Information for decision on adoption	Knowledge distributed through personal and formal channels	Standard creation and diffusion are separated
H. Actor Network Theory (Callon et al. 1986; Latour 1987)	Analysis of choices/ paths. Passage points/ gatekeepers	Alignment of interests	Human and non-human actors have equal explanatory power. No micro-macro divide	Mostly descriptive

Table 2. Theories Explaining Standard Creation and/or Diffusion Process

	Economic				Social			
Theory (See Table 1)	A	B	C	D	E	F	G	H
Addresses: **(1) standard creation/ selection,** **(2) standard diffusion/ selection**	(1)	(2)	(1) OR (2)	(1) OR (2)	(1)	(1) OR (2)	(1) OR (2)	(1) AND (2)

One challenge in case study research is the generalizability of the results derived from a limited number of cases. We believe our findings to be generalizable due to the proper selection of the cases. Our cases represent a good overview of different standardization modes on a continuum ranging from market driven *de facto* standardization to committee driven standardization. The three cases differ significantly in the complexity of the technology involved, the number of industries, individuals and firms involved, and the time length of the standardization process. Furthermore, the three processes cover the last three decades, namely, the 1970s, 1980s, and 1990s, during which time organizational structures have changed significantly, what has inevitably led to changes in the underlying processes, including the inter- and intra-organizational standardization processes.

3.2 Case Overviews

Our first case is the Nordic Mobile Telephone (NMT) system. The case of the NMT standard is an excellent example of a successful standard-making process (Fomin and Lyytinen 2000). There are several reasons why it is an interesting case for analysis. First, it was created at the time when there was a market demand for this kind of technology, but the needed technology was not yet available (Toivola 1992). Second, it was developed almost at the same time as another major cellular telephony standard, namely AMPS[5] in the U.S., but witnessed much greater acceptance and success (West 2000). The developers of the NMT system gambled on the rapid advance of radio and micro-electronic technology and designed the system "for the future." They ignored the fear of a high level of uncertainty due to their ability to anticipate in 1969 that what national PTTs[6] had was *"really a technology for the 60s, and that wouldn't do it for the 1970s"* (Manninen and Fomin 1999). This move necessitated the PTTs to create close relationships with otherwise external producers of telephone, radio, and micro-electronics equipment. We believe there were important social and cultural implications in the standard settings, which facilitated the standard creation process and paved the way for the standard to be delivered to the market.

The second case presented, the GSM cellular telephony system, is interesting because of the political interests and ambitious aims of the European PTTs in the system's development process. As early as 1980, a shared opinion existed among European PTTs that each European country would benefit from the introduction of a pan-European system (Bekkers and Smits 1998; Meurling and Jeans 1994; Toivola 1992). Non-official discussions at a Paris meeting in 1980 revealed that CEPT[7] would be too cumbersome and slow to lead the standardization work of a common European mobile system (Manninen 1999; Toivola 1992). It resulted in establishing Groupe Spécial Mobile (GSM), a body subordinate to the Committee for Coordination and Harmonization (CCH). The aim of GSM was to harmonize technical and operative specifications for a public mobile system on the 900MHz frequency band (Toivola 1992). The creation of GSM would end the traditional European fragmentation and incompatibility in the mobile field (Mouly and Pautet 1992).

The third case we analyzed was the standardization of short-range radio technology. Already in the early 1990s, several electronics, information technology, and telecommunications firms were exploring the possibilities of connecting devices such as mobile phones, laptops and peripherals without using wires. Several technological alternatives were developed that addressed this challenge. In 1993, IrDA[8] was formed to create an infrared data interconnection standard. Primarily, companies from the computing and semiconductor industry sponsored this standard. Several portable computer manufacturers experimented with radio technology to address the problem that the infrared technology required a line of sight between devices. Manufacturers realized that a common standard would be needed for this technology. In 1997, four companies announced a consortium to develop and promote a standard that would use radio technology to connect devices. The consortium was organized so that the four aforementioned companies would develop the standard. Other companies were allowed to join the consortium as adopters. However, adopters would not have direct influence on the specifications. The initiative has been particularly successful. While other partly overlapping standards continue to exist, over 200 firms committed themselves as adopters to the specification when in September 1999 version 1.0 was released.

Table 3. Differences and Similarities of the Cases

Similarities	Complex networked standards (Bach 2000; Lyytinen and Damsgaard 1998)
	International/inter-organizational standard setting arena
	Aiming at wide geographic market area
Differences	The size of standardization fora (dozen, tens, hundreds of participants)
	The type of standard setting fora (committee, alliance)
	The type of standard *(de facto*, *de jure*; market driven, committee led)
	Cultural settings (Nordic, Europe, Cross-continental) (Kumar et al. 1998)
	Time span of establishing standard (two to 10 years)

[5]AMPS—Advanced Mobile Phone System.

[6] PTT—Post Telephone Telegraph, usually a state owned monopoly organization providing these services.

[7]CEPT—(Fr.) Conférence des Administrations Européenes des Postes et Télécommunications.

[8]IrDA—The Infrared Data Association.

Table 4. Theory Uses for Process Analysis: Primary Theory Applicability Analysis

Case	Type of standard/fora	Size of fora,[a] persons	Cultural settings	Time frame, years	Relevant theory for analysis[b]
1. NMT	Committee *de facto*	10-30	Nordic, homogeneous	10+	C, G, H
2. GSM	Committee *de jure*	30-100	European, heterogeneous	10+	A, C, F, G, H
3. Wireless link	Alliance *de facto*	10+	Cross-continental, heterogeneous	2	A, B, D, H

[a]Number of people in technical committee responsible for development of specifications.
[b]Based on Table 1.

We show similarities and differences between the cases in Table 3. We use the similarities to unite the three cases logically. The differences are used to propose uses of relevant analysis theories, based on Table 4. In the next section, we will make a more detailed analysis of the cases and show that, for an adequate account of the standardization process, use of the pre-supposed theories does not suffice and a broader theoretical address is needed. By doing that, we also bring forth our integrated theory of standard making process.

3.3 Standardization as a Socio-Economic Process in Inter-Organizational Structures

Standardization takes place within organizational and inter-organizational structures. The design of these structures is one of the key choices that influences the outcome of any standardization process. The design and the outcome of processes for standardization would seem to be influenced by economic, social, and political forces (Schoechle 1999). In line with Granovetter's (1985, 1992) arguments these forces cannot be separated, but are embedded in each other. This embeddednes becomes apparent in the choice of partners in the wireless link case study:

> [3.1][9] *When the consortium was formed, of course there was the discussion what is the optimum size for this kind of consortium. First, it has to be so big and it has to have [such] strong players that it really has the market and has the weight on the media and all those things that are important.*

Participants of the initially small network looked for actors in the external environment that could help to start the bandwagon process necessary to establish a standard in a market.

> [3.2] *Second, if it is very big at the beginning there is the threat that it makes the actual work more difficult and more bureaucratic. If in every meeting there are representatives of twenty companies, it quickly turns out that each of them has different interests and conflicting interests and so it's making the progress of the actual standard slower.*

The passage shows that the organizational structures must be transformed over time due to conflicting requirements during different stages of the standardization process.

The way in which diffusion channels are implemented in the standard inception phase is seen from the continuation of the quotation from above:

> [3.3] *The idea was that there had to be players from the different parts of the game…from the telecom and from the computing industry. And players…strong enough that their market share in their business area is big enough so that it has a real meaning when the standard is finalized.*

[9]Numbers in brackets are given as follows: Case #, Passage #; e.g., in this case the designation [3.1] stands for Case 3 (radio link), Passage 1.

Political forces driving the standardization process are different from economic or socio-technological ones. The more actors involved in tzhe process, the more difficult it is to find a rationale behind the decision making. The citation below shows how political forces compete with social and economic forces in standardization:

> [2.1] *In February 1987, we had a meeting which ended in disagreement. Germans and French wanted a wide-band system, and the rest of the Europe wanted a narrow-band system. The technical people in GSM agreed we should have this narrow-band system. But political people in Paris and Bonn dictated the opinions of PTTs.*

The example above also points to the absence of equilibrium between the macro and micro organizational layers (Fomin 1999; Fomin and Lyytinen 2000).

> [2.2] *These nations' representatives were instructed to vote for the wide-band system. Of course, the ministers who took the decisions were not present. And they had a lot of political reasons. They've spent a lot of money on the experimental systems and they wanted to get something for their money.*

The example shows that there is not necessarily fair technical competition when choosing a particular standard. The selection process can be driven by politics as well.

Table 5 (and later Tables 6 and 7) show that the theories, initially determined to be adequate for the case analysis, do not suffice the inquiry. Additional theories must be used for comprehensive analysis.

Table 5. Secondary Theory Applicability Analysis

Case. Passage	Relevant theory	Not mentioned in Table 4
3.1	Bandwagon (D)	-
3.2	Bandwagon (D), standard selection (A), power relations (**F**), knowledge creation (**G**)	**F, G**
3.3	Increasing returns (C)	-
2.1	Alliance formation (**B**), power relations (F), knowledge creation (G), actor network theory (H)	**B**
2.2	Alliance formation (**B**), power relations (F), knowledge creation (G), actor network theory (H)	**B**

3.4 Standardization as a Sense Making and Conversation Process

Standards are **boundary objects** (Star and Griesemer 1989) that help create meaningful conversations between otherwise unconnected actors. Through working on standards, actors can create new common understanding, e.g., the equipment manufacturers originally conceived of the radio-link standard as a way to overcome problems that the existing infrared standard posed. By discussing the details and challenges of the standard across industry boundaries, a sense making (Weick 1995) process took place. The very concept of what a wireless link standard is and how it would relate to existing products was fundamentally transformed during the process.

At the time when the first generation cellular mobile systems were created in Europe, due to technical, economic, and political reasons, the European cellular market became very fragmented. A pan-European standard would serve as a boundary object linking the otherwise fragmented markets into a single pan-European market.

In the case of NMT, manufacturers were not able to foresee the scale of the production, and its developers had to enroll the help of industry in order to construct the needed technological solutions:

> [1.1] *With manufacturers we [PTTs/mobile operators to be] had different objectives. They've got shareholders, and if the manufacturer does not make a profit, it will be decapitated by shareholders. On the other hand, a mobile operator must think of a lot of other aspects: he has to make it as cheap and attractive as possible for the suppliers or customers, but can also think on a long-term basis.*

The need to create shared meaning and understanding is often so strong that it blurs the traditional boundaries of competition. For instance, one interviewee in the wireless radio link case study pointed out that working with a competitor from the same industry was easier than working with the other partners. In contrast to Schumpeterian theory, which posits that innovation is driven by competition and market selection, the case of NMT proves that the main impetus for innovation can come from cooperative practice as well:

> [1.2] *[The development of the NMT] was driven by enthusiasm. And we did not look at the commercial side. Well, we did look, but it was not about the competition. We were cooperating, no fights, we had support from the top management—it was driven by a common goal. And we saw that the only way to get this all to operation was by working together—we could not do it separately. [The project was] too big and the suppliers would not support us.*

In this section, the analysis provides insights into why economic reasoning is not sufficient for the analysis of standard making. The meaning of a standard as a boundary object (Fomin and Lyytinen 2000) helps us to understand how different parties with conflicting interests might come together.

Table 6. Secondary Theory Applicability Analysis, Continued

Case. Passage	Relevant theory	Not mentioned in Table 4
1.1	Increasing returns (C)	-
	Diffusion of innovation (**E**)	E
1.2	Knowledge creation (G)	-

3.5 Standardization as a Negotiation Process

Aside from being tied to structures, and dependent on joint sense making, the standardization process can also be conceived of as a negotiation process. Only through a process of negotiation and compromise it is possible to create a standard that can be diffused successfully. The negotiated need for a common standard makes it possible to bridge different visions and perceptions, and thus acts as a mediator between the needs of the involved parties. We see the negotiation process as political in nature rather than as an economic or technological imperative. The following example shows how communication channels between the core standard development group and external actors were established:

> [1.3] *We sent specifications to almost 200 addresses all over the world....Our philosophy was always to communicate with industry, get their feedback, but we made the decisions....Later we sent specifications also to component manufacturers, because if we had sent specifications only to mobile manufacturers, they would have thought of it in a different way and made the solutions in different ways.*

Even though this quote represents a recollection of processes that took place in the 1970s, there have already been similar examples in the previous sections from the 1990s, related to the wireless radio access case study.

The alignment of interests is not necessarily performed through a boundary object (a standard in our case). Negotiation also has a function of assigning needed resources to the standard-making process. A peculiar case was disclosed in one interview. It shows how different institutions and centers of power can reach an agreement without having a common aim:

> [1.4] *The frequency problem caused Sweden a lot of difficulties, because the 450 [MHz] band was the most suitable for Norway and Denmark, and Finland. But in Sweden, the 450MHz band was blocked by military people. Whilst it was available in times of peace, it had to be held "on ice." So it was a true collision [of interests], but after a year or so, Swedish military people said "OK, you can use it in the peace time." We haven't had a war after that, so it worked out quite well.*

This quote shows that the interest negotiation process is about aligning different interests, whether economic, political, or other. The negotiation process is about resolving the conflicts associated with the resources needed for the standard making process to evolve.

Table 7. Secondary Theory Applicability Analysis, Continued

Case. Passage	Relevant theory	Not mentioned in Table 4
1.3	Diffusion of innovation (**E**)	E
	Knowledge creation (G)	-
	Actor network theory (H)	-
1.4	Power relations (**F**)	F
	Actor network theory (H)	-

Table 8. Theory Applicability Mapping

	Case. Passage								
Theory	1.1	1.2	1.3	1.4	2.1	2.2	3.1	3.2	3.3
A: Game theory: standard selection									
B: Game theory: alliance formation					x	x			
C: Increased returns	x								x
D: Bandwagon							x	x	
E: DOI	x		x						
F: Power relations				x	x	x		x	
G Knowledge creation		x	x		x	x		x	
H: ANT			x	x	x	x			

Table 8 is used to confirm our proposition that, in our case, none of the theories used for analysis of standardization processes could adequately explain complex IT/IS standardization processes (no one theory could address all of the passages).

4. CONCLUSIONS

In the empirical part of this paper, we examined standard making processes, which spanned over three decades beginning from the late 1960s to the present. We looked at different forces shaping the decision-making processes, at the enrolment of actors, at the sense-making process, and, finally, at how the interests of different parties were aligned during the negotiation process. Economic or social theories alone cannot explain fully the passages of standardization processes presented in the paper. The approach we presented encompasses arguments from both groups of theories. This approach allows us to analyze the whole standardization process, from the inception of an idea to the implementation in the market, while most of the previous research looked at these processes in separation as independent knowledge creation and diffusion cycles (Farrell and Saloner 1988; Rogers 1995).

User participation in the standardization process is becoming more important. The relevance of our findings to the IS community is brought about by the fact that CIOs can become participants of standardization committees. Knowing the needs of the user communities they represent, CIOs should take an active role in negotiations on establishing standards in, for example, B2B commerce, software purchases, etc. High stakes and risks are juxtaposed to promises of network benefits (Bach 2000). By combining the "post"-economic and social arguments on management phenomenon, we are trying to understand the role and impact of users in the standard making process.

The approach presented in the paper shows that standardization practices can be analyzed successfully regardless of the dominant contemporary organizational structures. While we believe in the robustness of our framework due to the case selection, it would seem important to test and further generalize our argument to other environments. In addition to applying the framework to other contexts, future research should try to further the theory integration. In particular, it would be important to improve our understanding under which circumstances social, economic, or political lenses should be worn.

References

Anderson, P., and Tushman, M. L. "Technological Discontinuities and Dominant Design: A Cyclical Model of Technological Change," *Administrative Science Quarterly* (35), 1990, pp.604-633.

Arthur, W. B. "Competing Technologies, Increasing Returns, and Lock-In by Historical Events," *The Economic Journal* (99), 1989, pp.116-131.

Axelrod, R., Mitchell, W., Thomas, R. E., Bennet, D. S., and Bruderer, E. "Coalition Formation in Standard-Setting Alliances," *Management Science* (41:9), 1995, pp.1493-1508.

Bach, D. "International Cooperation and the Logic of Networks: Europe and the Global System for Mobile Communications (GSM)," Working Paper BRIE #139/ Economy #14, University of California, Berkeley, 2000.

Bekkers, R., and Smits, J. *Mobile Telecommunications: Standards, Regulation, and Applications*, Boston: The Artech House, 1998.

Besen, S. M., and Farrell, J. "Choosing How to Compete: Strategies and Tactics in Standardization," *Journal of Economic Perspectives* (8:2), 1994, pp.117-131.

Callon, M. "Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St Brieuc Bay," in *Power, Action and Belief: A New Sociology of Knowledge?*, J. Law (ed.), London: Routledge & Kegan Paul, 1986, pp. 196-229.

Callon, M. "The Dynamics of Techno-Economic Networks," in *Technological Change and Company Strategies: Economic and Sociological Perspectives,* P. S. Rod Coombs, V. Walsh (eds.), San Diego: Harcourt Brace Jovanovich, Publishers, 1992, pp. 72-102.

Callon, M., Latour, B., and Rip, A. (eds.). *Mapping the Dynamics of Science and Technology*, Basingstoke, England: Macmillan, 1986.

Callon, M., and Law, J. "On the Construction of Sociotechnical Networks: Content and Context Revisited," *Knowledge and Society* (8), 1989, pp.57-83.

Choh, K. "Innovation and Standardization in Technological Trajectories: A Schumpeterian Perspective and Three Models of Standardization in the Information Technology Industry," in *Proceedings of First IEEE Conference on Standardization and Innovation in Information Technology,* K. Jakobs (ed.), Aachen, Germany, 1999.

Cowan, R., and Foray, D. "The Economics of Codification and the Diffusion of Knowledge," *Industrial and Corporate Change* (6:3), 1997, pp.595-622.

David, P. A., Greenstein, S. "The Economics of Compatibility Standards: An Introduction to Recent Research," *The Economics of Innovations and New Technology* (1:1/2), 1990, pp.3-41.

Eisenhardt, K. M. "Building Theories from Case Study Research," *Academy of Management Review* (14), 1989, pp.532 - 550.

Farrell, J., Monroe, H. K., and Saloner, G. "The Vertical Organization of Industry Systems Versus Component Competition," Research Paper Series # 1329, Stanford Business School, Stanford University, 1994.

Farrell, J., and Saloner, G. "Coordination Through Committees and Markets," *The RAND Journal of Economics* (19:2), 1988, pp.235-252.

Fomin, V. V. "The Dynamics of Standard Setting: Equilibrium and Transformation in Social Networks," in *Proceedings of First IEEE Conference on Standardization and Innovation in Information Technology*, K. Jakobs (ed.), Aachen, Germany, 1999,

Fomin, V. V., and Lyytinen, K. "How to Distribute a Cake Before Cutting it into Pieces: Alice in Wonderland or Radio Engineers' Gang in the Nordic Countries?," in *Information Technology Standards and Standardization: A Global Perspective,* K. Jakobs (ed.), Hershey, PA: Idea Group Publishing, 2000.

Ghoshal, S., and Moran, P. "Bad for Practice: A Critique of the Transaction Cost Theory," *Academy of Management Review* (21:1), 1996, pp.13-47.

Glaser, B., and Strauss, A. *The Discovery of Grounded Theory: Strategies for Qualitative Research*, London: Wiedenfeld and Nicholson, 1967.

Granovetter, M. "Economic Action and Social Structure: The Problem of Embeddedness," *American Journal of Sociology* (91:3), 1985, pp.481-510.

Granovetter, M. "Problems of Explanation in Economic Sociology," in *Networks and Organizations: Structure, Form, and Action,* N. Nohria and R. G. Eccles (eds.), Boston: Harvard Business School Press, 1992, pp. 25-56.

Heikkilä, J. *The Diffusion of a Learning Intensive Technology into Organizations: The Case of Personal Computing*, Unpublished Doctoral Dissertation, Helsinki School of Economics and Business Administration, Finland, 1995.

Kumar, K., van Dissel, H. G., and Bielli, P. "The Merchant of Prato—Revisited: Toward a Third Rationality of Information Systems," *MIS Quarterly* (22:2), 1998, pp.199-226.

Latour, B. "Ethnography of a 'High-Tech' Case: About Aramis," in *Technological Choices: Transformations in Material Culture Since the Neolithic,* P. Lemannier (ed.), London: Routledge and Kegan Paul, 1993, pp. 372-398.

Latour, B. *Science in Action: How to Follow Scientists and Engineers Through Society*, Milton Keyes, England: Open University Press, 1987.

Lyytinen, K., and Damsgaard, J. "What's Wrong with the Diffusion of Innovation Theory? The Case of Complex and Networked Technology," Working Paper, University of Jyväskylä, Finland, 1998.

Manninen, A. "History of the Nordic Mobile Telephone System's Development," Unpublished Report, University of Jyväskylä, Finland, 1999.

Manninen, A., and Fomin, V. V. "Interview with Thomas Haug on the NMT and GSM Systems' Development," Unpublished Interview, University of Jyväskylä, Finland, 1999.

Meurling, J., and Jeans, R. *The Mobile Phone Book*, London: Communications Week International, 1994.

Michelis, G. D. "Cooperation and Knowledge Creation," in *Comparative Study of Knowledge Creation,* I. Nonaka and T. Nishiguchi (eds.), New York: Oxford University Press, 1997.

Mouly, M., and Pautet, M.-B. *The GSM System for Mobile Communications*, Palaiseau, France: Michael Mouly and Marie-Bernadette Pautet, 1992.

Nonaka, I., and Takeuchi, H. *The Knowledge Creating Company*, New York: Oxford University Press, 1995.

Pinch, T. "Understanding Technology: Some Possible Implications of Work in the Sociology of Science," in *Technology and Social Process,* B. Elliott (ed.), Eidenburgh: Edinburgh University Press, 1988.

Rogers, E. M. *Diffusion of Innovations* (4th ed.), New York: The Free Press, 1995.

Schilling, M. A. "Technological Lockout: An Integrative Model of the Economic and Strategic Factors Driving Technological Success and Failure," *Academy of Management Review* (23:2), 1998, pp.267-284.

Schoechle, T. "Toward a Theory of Standards," in *Proceedings of the First IEEE Conference on Standardization and Innovation in Information Technology,* K. Jakobs (ed.), Aachen, Germany, 1999.

Star, S. L. "Power, Technologies and the Phenomenology of Conventions: On Being Allergic to Onions," in *A Sociology of Monsters: Essays on Power, Technology and Domination,* J. Law (ed.), London: Routledge, 1991.

Star, S. L., and Griesemer, J. R. "Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39," *Social Studies of Science* (19), 1989, pp.387-420.

Toivola, K. *Highlights of Mobile Communications Development*, Helsinki: TELE, 1992.

Tushman, M. L., and Anderson, P. "Technological Discontinuities and Organizational Environments," *Administrative Science Quarterly* (31), 1986, pp.439-465.

Tushman, M. L., and Rosenkopf, L. "Organizational Determinants of Technological change: Toward a Sociology of Technological Evolution," in *Research in Organizational Behavior,* B. M. Staw and L. L. Cummings (eds.), Greenwich, CT: JAI Press, 1992, pp. 311-347.

Wade, J. "A Community-level Analysis of Sources and Rates of Technological Variation in the Microprocessor Market," *Academy of Management Journal* (39:5), 1996, pp.1218-1244.

Wade, J. "Dynamics of Organizational Communities and Technological Bandwagons: An Empirical Investigation of Community Evolution in the Microprocessor Market," *Strategic Management Journal* (16:Special Issue), 1995, pp.111-133.

Weick, K. E. *Sensemaking in Organizations*, London: Sage, 1995.

West, J. "Institutional Constraints in the Initial Deployment of Cellular Telephone Service on Three Continents," in *Information Technology Standards and Standardization: A Global Perspective,* K. Jakobs (ed.), Hershey, PA: Idea Group Publishing, 2000 .

Williams, R. "The Social Shaping of Information and Communication Technologies," in *The Social Shaping of Information Superhighways: European and American Roads to the Information Superhighway,* H. Kubicek, W. H. Dutton, and R. Williams (eds.), Frankfurt: Campus, 1997, pp. 299-338.

Williams, R., and Edge, D. "The Social Shaping of Technology," *Research Policy* (25), 1996, pp.865-899.

Yin, R. K. *Case Study Research. Design and Methods* (2nd ed.), Thousand Oaks, CA: Sage Publications, Inc., 1994.